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International application number: PCT/US05/003025

International filing date: 26 January 2005 (26.01.2005)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/539,427
Filing date: 26 January 2004 (26.01.2004)

Date of receipt at the International Bureau: 28 June 2005 (28.06.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

US04/0087 Q WO
PCT/US05/03025

PA 1280864

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APPLICATION NUMBER: ***60/539,427***
FILING DATE: ***January 26, 2004***

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17157 U.S.PTO

Attorney Docket No. **US040087Q**

22154 U.S.PTO
60/539427
012604

PROVISIONAL APPLICATION COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.:	**EV417138622US**

1. INVENTOR(S)

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2. TITLE OF THE INVENTION

FREQUENCY GENERATION FOR A MULTI-BAND OFDM BASED ULTRA WIDE-BAND RADIO

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24738
PATENT TRADEMARK OFFICE
CUSTOMER NUMBER

4. ENCLOSED APPLICATION PARTS

☒ Specification (**15 pages**)
☒ Drawing(s) (**0 sheet(s)**)
☒ Return-Receipt Postcard

5. METHOD OF PAYMENT

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number **14-1270.** Filing Fee Amount: **$160**

Date 1/26/04

Respectfully submitted,

By [signature]
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Philips Intellectual Prop rty & Standards

ID 779572
US04 0087Q

Invention Disclosure
Version 2.0.0 21-08-2003

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Title of the invention: Frequency Generation for a multi-band OFDM based ultra wide-band radio

Inventors' name(s) + e-mail address(es): Helen Waite + Yifeng Zhang
Helen.waite@philips.com

Abstract of the invention:
(detailed description to be provied on next page)

These ideas are for implementation of a multi-band Ultra-Wide Band (UWB) Radio. They pertain to the frequency generation of hopping sequence of three frequencies required to drive the downconversion within the radio. The multi-band UWB system requires the generation of a series of frequencies (3 at 3432MHz, 3960MHz, 4488MHz for a 3 band system). The system frequency hops between the three bands. The hopping occurs every 312ns. Achieving the required switching time from a conventional VCO/PLL arrangement is not feasible, and hence alterative architectures are needed to meet the frequency hopping requirements. The idea here make use of two VCOs to generate two of the three bands, and an arrangement with a single sideband mixer, to generate the remaining band. VCOs. The frequency planning for the VCOs and dividers has been carefully chosen to generate all the required frequencies using only a single mixing stage for sub-band #2, but otherwise avoids the use of mixing with only two VCOs. The idea encompasses both the architecture and the specific frequency plans shown for implementation for an ultra wide-band radio.

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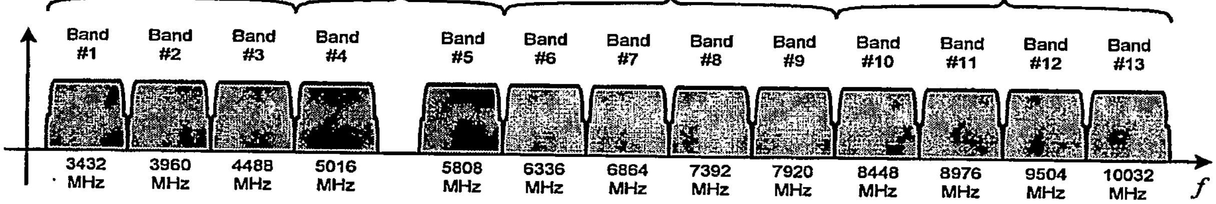
Detailed description of the invention

Please describe the invention using the headings below

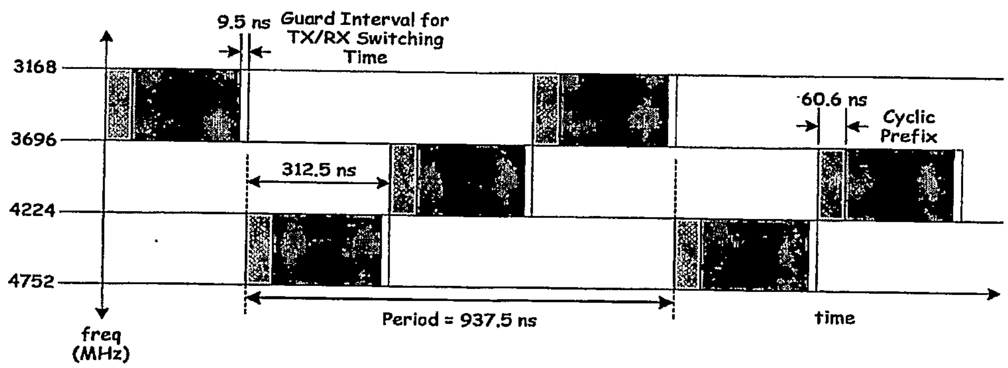
Background of the invention

This invention is for implementation of a multi-band OFDM ultra wide-band radio. It pertains to the frequency generation required to drive the down-conversion mixers. For a multi-band OFDM radio frequency hopping is used, with a hop in frequency every 312ns. The time taken to change frequency in the radio must be much shorter than the hopping period, in the order of a few nano-seconds. The hopping scheme uses three bands and requires frequency generation at 3432MHz, 3960MHz, and 4488MHz. The multi-band OFDM ultra wide-band radio is described in the IEEE document 15-03-0267-06-003a-Multi-band-OFDM-CFP-Presentation.ppt and 15-03-0268-01-003a-Multi-band-CFP-Document.pdf

Banding for multi-band OFDM radio : three band option use three sub-bands in group A.



Frequency hopping example for three band radio (alternative frequency hopping order is also possible)



Conventionally, a VCO controlled by a PLL is used for frequency generation. However due to the very fast switching time required for UWB this is not feasible, and an alternative approach is required. An Alternative approach has been proposed using a single VCO and generating the required frequencies via a series of

dividers and mixing stages. This approach is described in 15-03-0267-06-003a-Multi-band-OFDM-CFP-Presentation.ppt (page 20/51). However, it requires multiple divider stages, and also multiple single side band mixers. The use of single side band mixers will result in undesired spurious products, and the greater the number of mixers in the approach the more spurious products generated. Filtering can be employed to reduce such spurious responses, but this increases complexity, and can have a negative impact on power consumption.

This idea make use two VCOs to generate the frequencies at 3432MHz and 4488MHz, whilst the third is generated with a single sideband mixer, or a complex mixer. The third frequency is generated via the mixing at 3960MHz. As this is the middle frequency band of the three bands, this is the optimal one to generate via mixing, since it is located furthest from out of band interferers, and hence filtering of spurious products created by the mixing is avoided.

The frequency planning for the fixed frequency generators and dividers has been carefully chosen to generate all the required frequencies using **only one single mixing stage, and only requiring this mixing for generation of one sub-band, that is located in between the other two sub-bands, and thus furthest from interferer signals, and makes the filtering of undesired spurious responses easiest**

Problems or disadvantages overcome by the invention

Usually an invention solves a particular problem or removes some disadvantage of known methods/devices etc. Are the disadvantages/problems new or were they already known?

This invention minimises the generation of spurious products, removing the issue for two of three sub-bands, and easing it for the remaining sub-band. It uses an architecture and frequency plan that requires only a single mixing stage, and two VCOs The only existing known prior art uses multiple mixing stages, which will result in the generation of more spurious products. These spurious products can be dealt with via filtering, but there are practical limitations to how much the spurious products can be filtered, and the filtering increases the complexity of the solution. A previous disclosure (ref export control no 5E991, date 30 Sept 03) proposes using a single SSB mixer, but this is required to generate two of the three sub-bands. This idea has the further benefit of providing both VCO frequencies directly, and generating the third frequency only via mixing.

The idea we propose also minimises the need for filtering. The generation of spurious products in mixers is well known, and the need for filtering to suppress such products is also known. With respect to ultra-wide band radios, it is unclear at the present time whether those planning on using multiple mixing stages will really be able to meet the spurious requirements with the schemes.

The essential feature(s) of the invention

The measures/device features that are proposed to solve the problem, and the resulting advantages. If the invention is based on a new understanding (insight), please indicate this.

The essential features of this invention are as follows :

- it provides a method for generating multiple frequencies for a frequency hopping UWB system through fixed frequency generators and a single mixing stage
- it allows very fast switching between the different frequencies required (since PLL settling is not required)
- it avoids the problem of spurious products completely for two of the three sub-bands
- it minimises the generation of spurious products by using only a single mixing stage, rather than multiple mixing stages, and the frequency band that needs to be generated via the mixing allows for the best

opportunity to filter unwanted spurious responses, based on it's located relative to that of interferer frequency bands.

- it reduces the filtering requirements for spurious products by using only a single mixing stage, and therefore decreases the complexity when compared with other schemes using multiple mixing stages.
- It allows more relaxed spurious requirements, since they will only be an issue for 1/3 of the time (on one sub-band) and so the system will be more immune to loss of sub-carriers as a result of spurious products, since they will be lost only on one sub-band.

Detailed description of how to build and use the invention

For a three band radio, the idea is to use fixed frequency generators are at 3432MHz and 4488MHz, or alternatively 6864MHz, and 8976MHz.

Sub-band one at 3432MHz is available directly from the first VCO, or via a divide by two circuit from the 6864MHz VCO.

Sub-band two at 3960MHz is generated by a single sideband or complex mixer taking the upper sideband at 7920MHz (3432 MHz + 4488MHz) and dividing by two. Alternatively sub-band #2 can be generated via a single sideband or complex mixer with inputs taken at 1716MHz (3432MHz divided by 2, or 6864MHz divided by 4), and 2244MHz(4488MHz divided by two, or 8976MHz divided by 4) to give directly at the mixer output the 3960MHz frequency(1716MHz + 2244MHz). Filtering could be applied at the mixer output to reduce spurious responses, particularly those that lie close to the 801.11a/j bands, and 801.11b/g bands, and cellular bands, which could create problems.

Sub-band three at 4488MHz is available directly from the first VCO, or via a divide by two circuit from the 8976MHz VCO.

Note : further diagrams are provided as a separate file in the disclosure documentation.

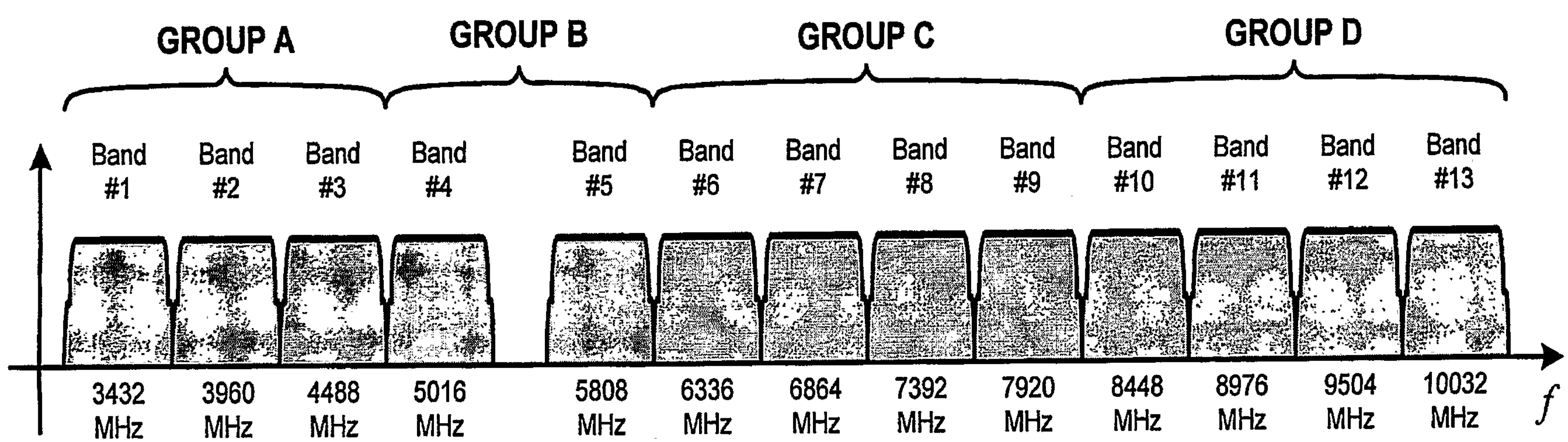
Applications of the invention

Indicate here in which fields (technical, commercial) the invention can be applied. Please include any references to Philips products or projects relate to the invention.

Semiconductors : Ultra wide-band radio IC (reference to the Cheetah project, currently in the study phase)
Philips CE : this invention pertains to the architecture for the radio IC required for UWB applications. CE plan to use UWB technology for wireless connectivity of CE products in the future.

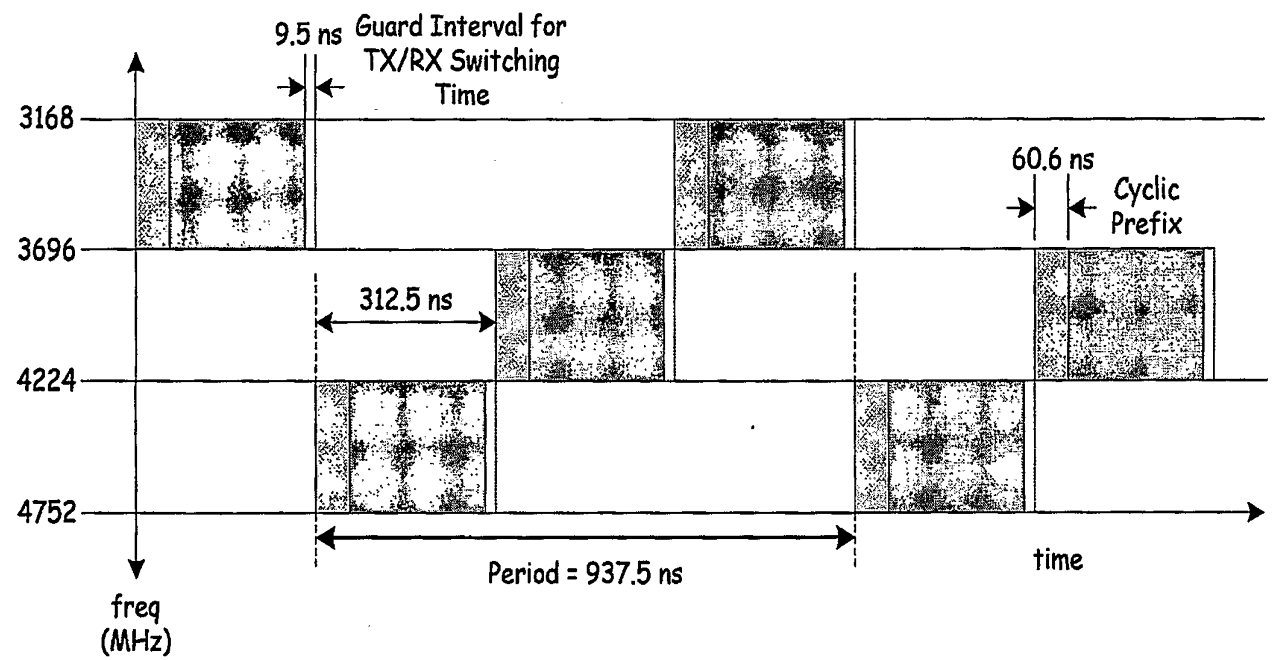
UWB Frequency Generation Requirements

- Spectrum is divided into 528 MHz sub-bands.
- Two mode of operation proposed
  - Mandatory using 3 bands (group A)
  - Optional using 7 bands (group A and group C)



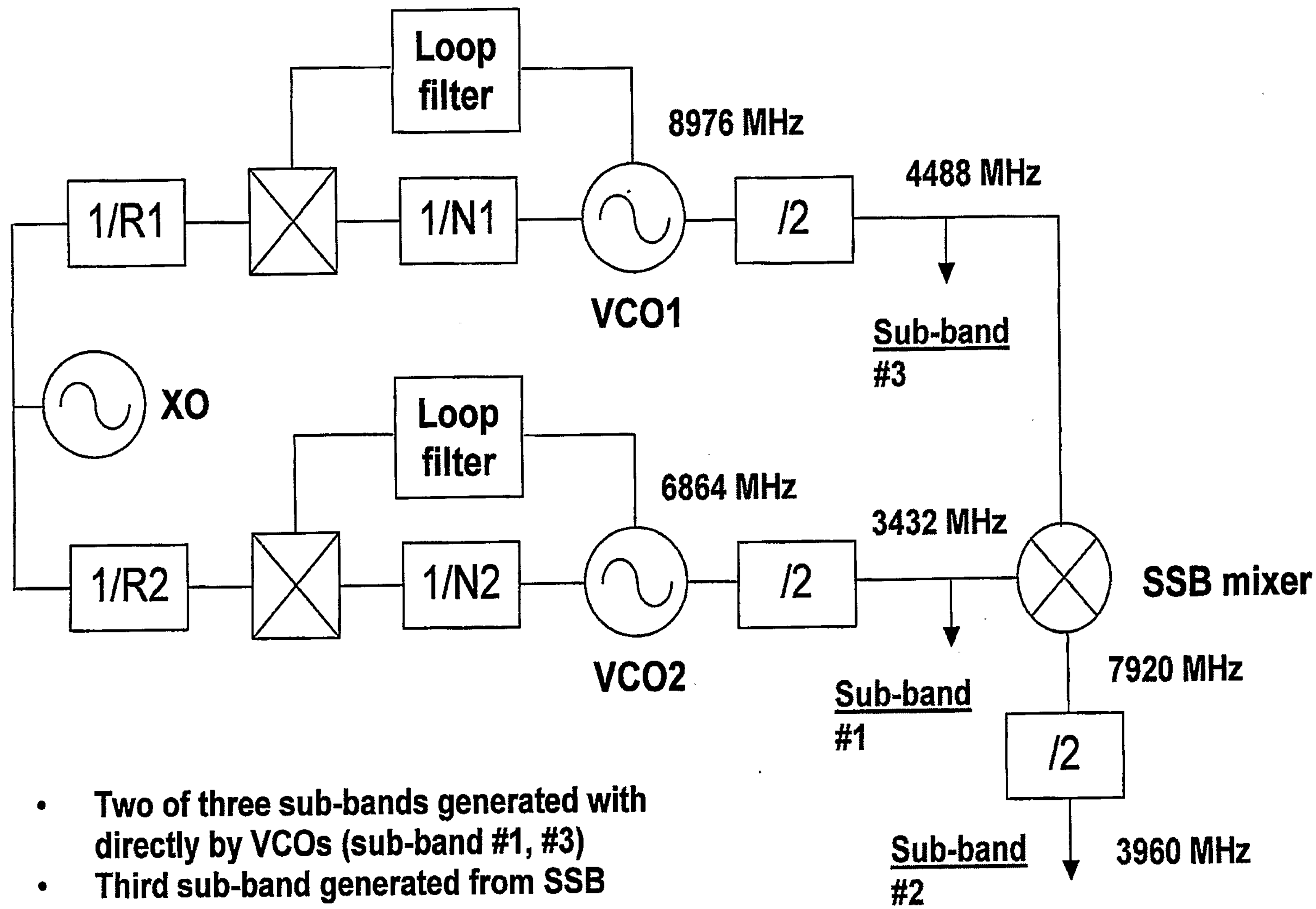
UWB Frequency Generation Requirements

- Frequency hopping scheme
  - Change frequency every 312ns
  - For 3 bands (shown below), hop between 3 sub-bands
  - For 7 bands, hop between 7 sub-bands



Options for frequency generation

Proposed Architecture for 3 bands – implementation "A"



- Two of three sub-bands generated with directly by VCOs (sub-band #1, #3)
- Third sub-band generated from SSB mixing (sub-band #2)

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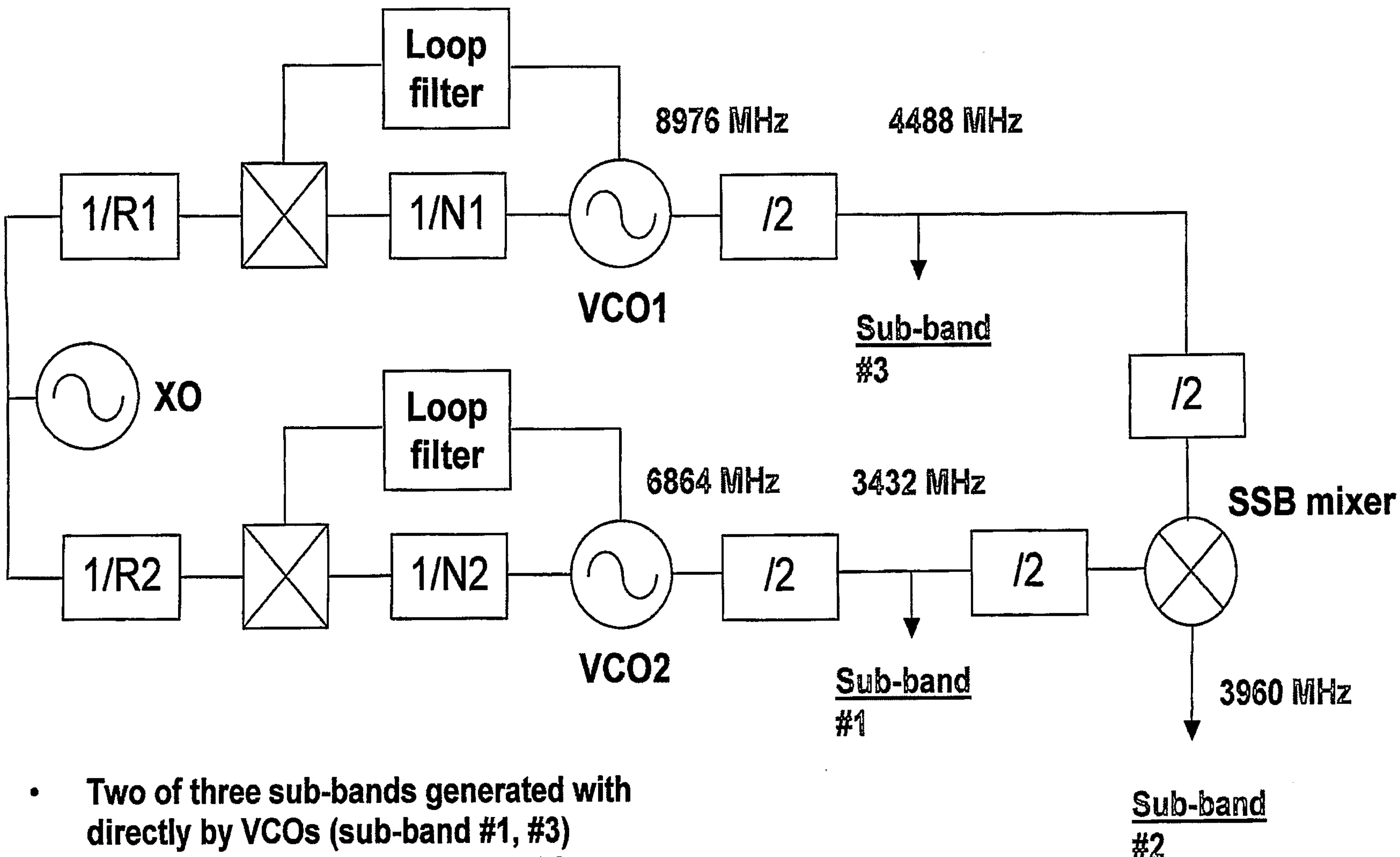
Options for frequency generation

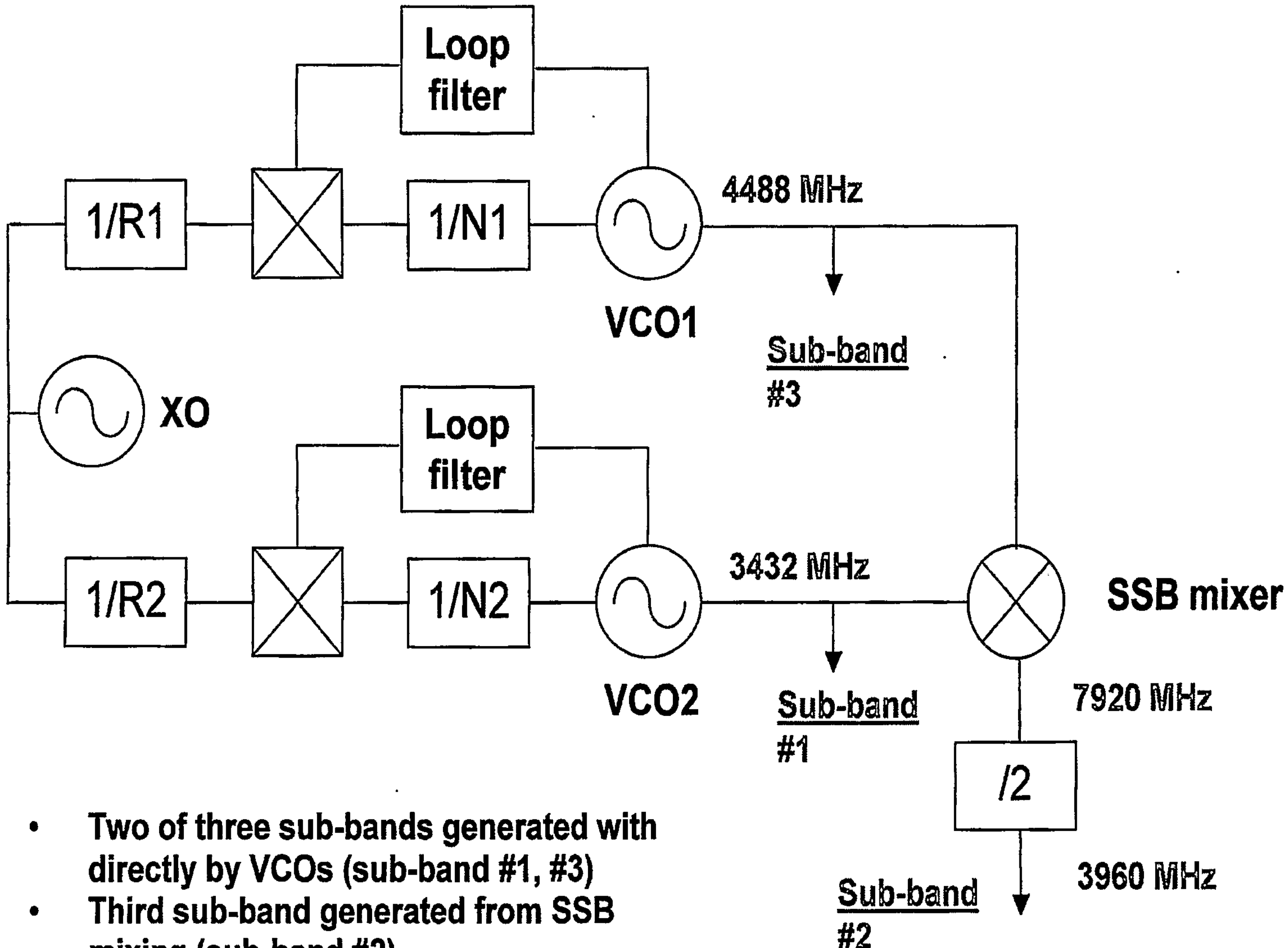
Proposed Architecture for 3 bands – implementation "B"



- **Two of three sub-bands generated with directly by VCOs (sub-band #1, #3)**
- **Third sub-band generated from SSB mixing (sub-band #2)**

Options for frequency generation

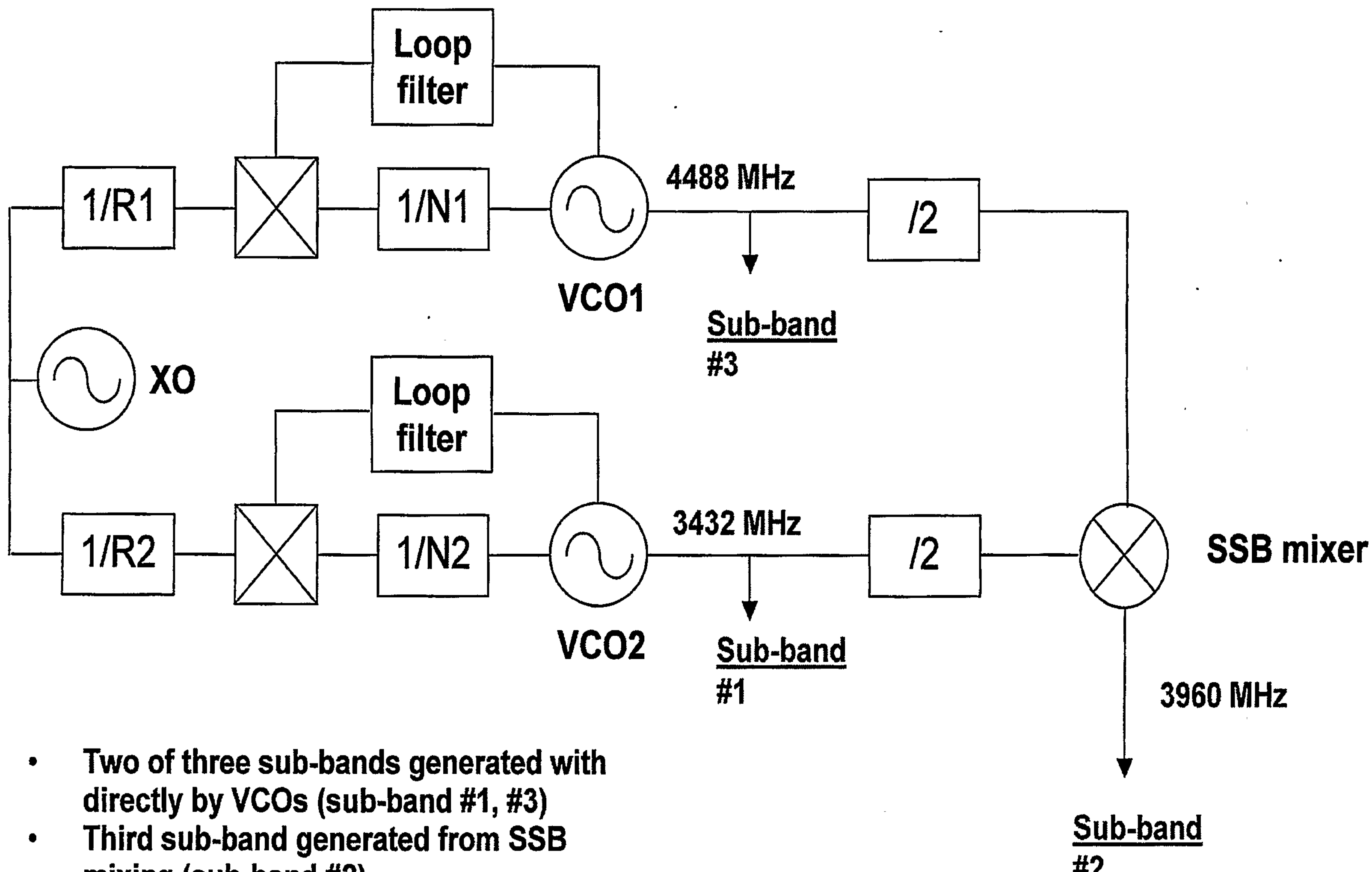
Proposed Architecture for 3 bands – implementation "C"



- Two of three sub-bands generated with directly by VCOs (sub-band #1, #3)
- Third sub-band generated from SSB mixing (sub-band #2)

Options for frequency generation

Proposed Architecture for 3 bands – implementation “D”



- Two of three sub-bands generated with directly by VCOs (sub-band #1, #3)
- Third sub-band generated from SSB mixing (sub-band #2)

Options for 3 band frequency generation

Advantages over current state of the art (applicable for all options presented)

- Only sub-band #2 is generated using SSB mixing. The other two sub-bands (#1 and #3) are generated directly, so spurious products will not be an issue for sub-bands #1 and #3 (current state of the art uses SSB mixing for all sub-bands, Previous disclosure uses SSB mixing for two of three sub-bands)

- Sub-band #2 is further away from problem interferer frequency bands, and hence problem spurious signals can be more easily filtered than when generating sub-bands #1 and #3 via mixing

- Even for sub-band #2, some relaxation in spurious requirements may be possible since this will be the only sub-band with spur issues, but as it is only transmitting for 13 of the time, loosing some information from just this sub-band will have less impact on PER/BER than loosing it for all sub-bands

Options for 3 band frequency generation

Summary of each option

- Option A
  - Requires VCOs at 8976MHz and 6864MHz, however generates quadrature signals for each sub-band through divider circuits
  - SSB must operate to give USB product at 7920MHz
- Option B
  - Requires VCOs at 8976MHz and 6864MHz, however generates quadrature signals for sub-bands #1 and #3 through divider circuits
  - SSB operates to give USB product at 3960MHz, but must provide direct quadrature outputs
- Option C
  - Requires VCOs at 4488MHz and 3432MHz, but needs to provide quadrature outputs directly for sub-bands #1 and #3
  - SSB must operate to give USB product at 7920MHz, but quadrature output is generated by divider circuit provide
- Option D
  - Requires VCOs at 4488MHz and 3432MHz, but needs to provide quadrature outputs directly for sub-bands #1 and #3
  - SSB operates to give USB product at 3960MHz, but must provide direct quadrature outputs

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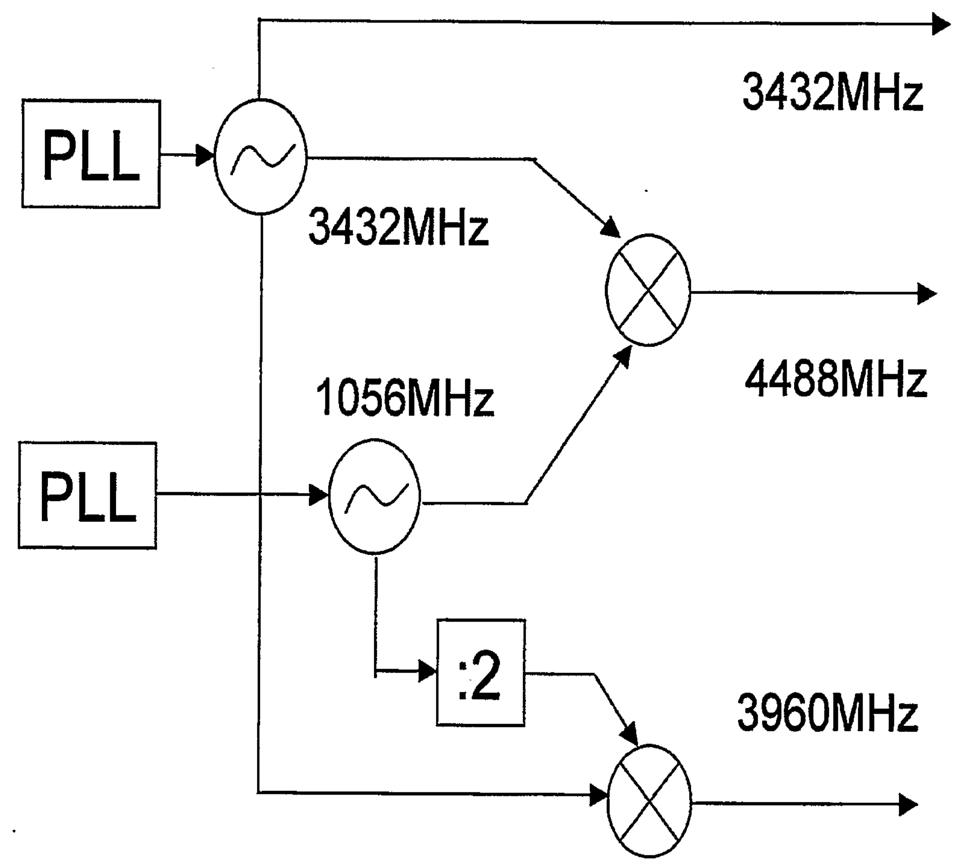
Block Diagram



Yifeng Zhang

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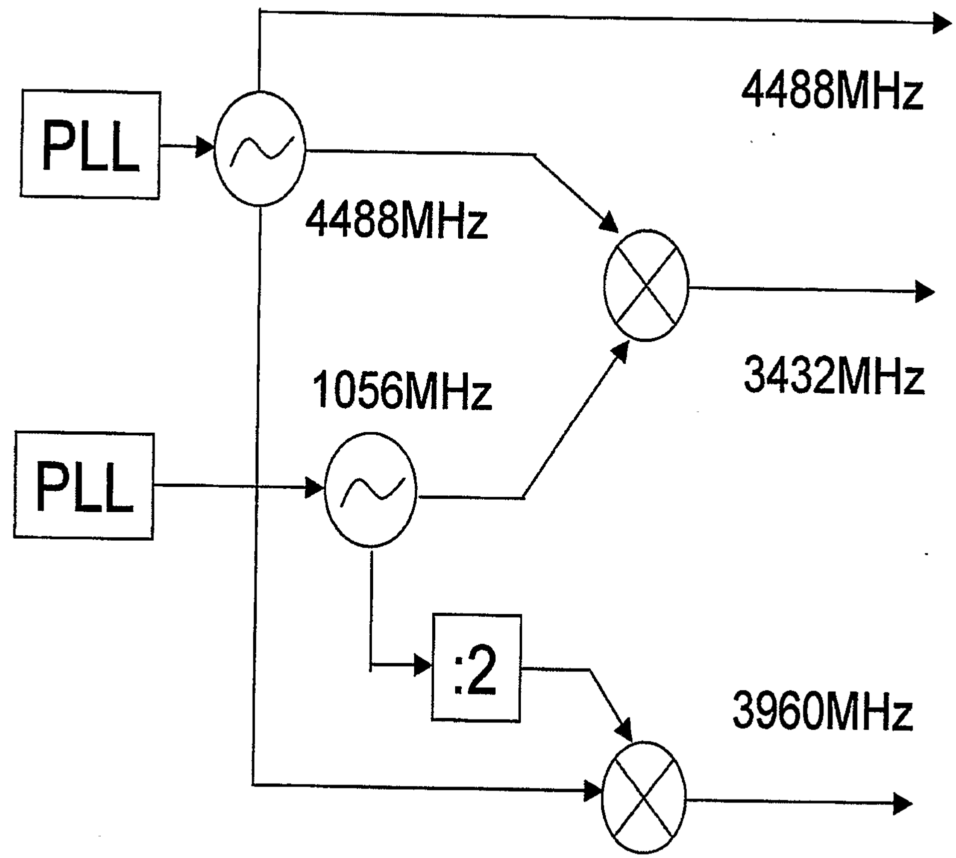
Block Diagram



Helen Waite

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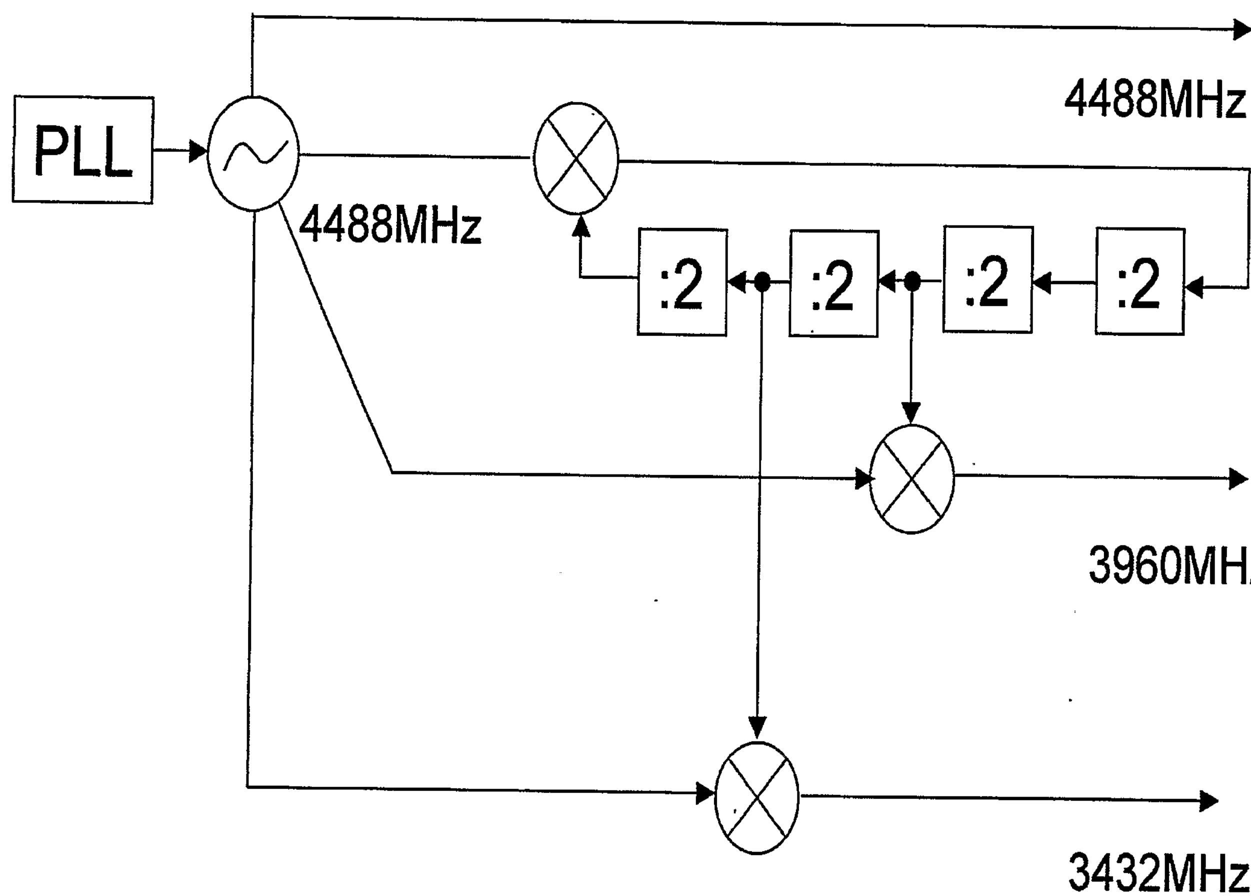
Block Diagram



Yifeng Zhang